Overview of the ATLAS High-Granularity Timing Detector : project status and results

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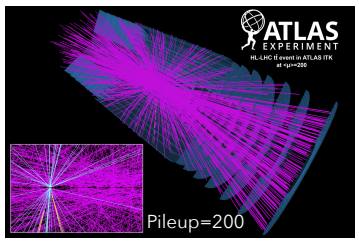
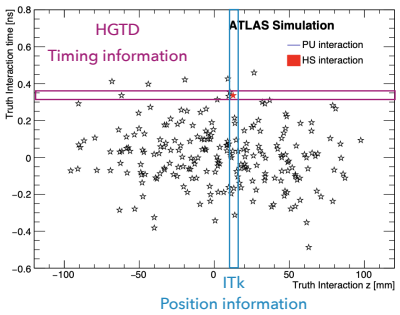
High-Luminosity LHC

In 2029, the high-luminosity phase of LHC will start

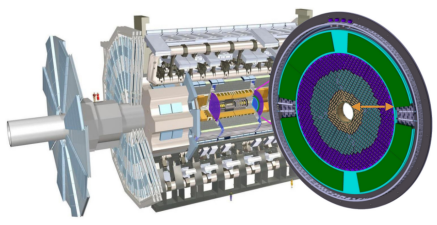
- Instantaneous luminosity up to 7.5 x 10^{34} cm^{-2} s^{-1}
- **Main challenge:** separate collisions very close in space (~1.6 vertices per mm)
- **Solution:** HGTD in the forward region of the ATLAS detector providing precise timing information combined to a full silicon tracker (ITk) providing high precision tracking

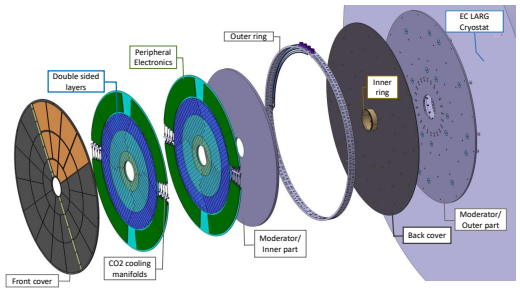




HGTD

- Two end-caps located at z ±3.5 m
- Active area : 2.4 < $|\eta|$ <4.0, 12 < R < 64 cm
- Each is two double-sided layers of modules mounted on cooling disks
- Target time resolution: 30 (50) ps per track, 35 (70) ps per hit at the start (end) of HGTD lifetime



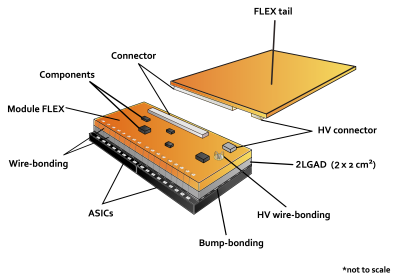


Module & Sensor

8032 modules: 2 silicon sensors bump-bonded to 2 ALTIROC (ATLAS LGAD Timing Integrated Read Out Chip) ASICs

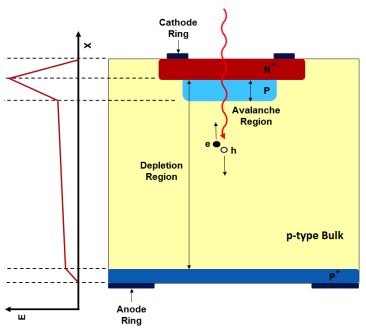
→ **Ongoing:** bench tests of ALTIROC2 modules on flex PCB

→ **Next step:** bench tests of ALTIROC3 modules (radiation hard version of ALTIROC2)



LGAD (Low Gain Avalanche Detector) : standard **n-p** silicon detector with additional **p-type doping layer**

- Size: 15x15 pads (1.3x1.3 mm^2 each) and 300 μm thick
- Time resolution: 30 (50) ps per track at the start (end) of HL-LHC
- Collected charge: 10 (4) fC at the start (end)

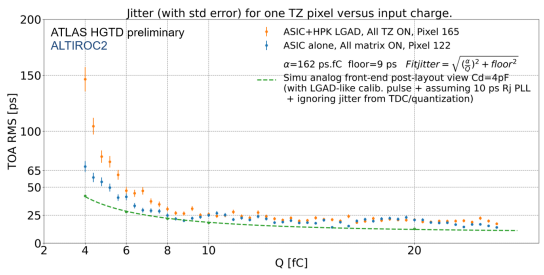


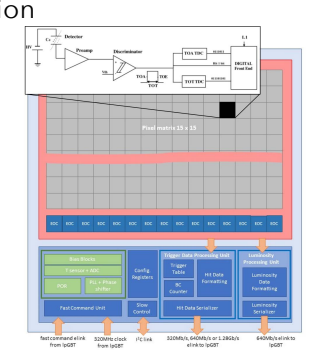
ALTIROC

- Provides time of arrival (TOA), time over threshold (TOT) and luminosity (number of hits per bunch crossing)
- Small jitter required: 25 ps at 10 fC, <70 ps at 4 fC
- ALTIROC3 bench tests were successful, robustness of the hybridisation needs to be tested

→ **Ongoing:** tests of ALTIROC3 (beam tests in autumn) and design of pre-production chip

→ **Next step:** ALTIROC chip pre-production



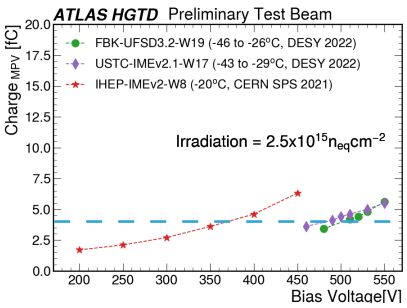


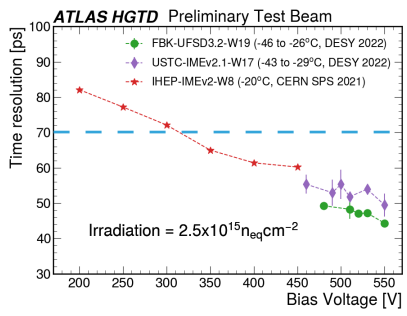
Sensor results

- End-of-lifetime studies on carbon-enriched LGADs and tests with e^- (DESY) and π (CERN-SPS) beams on irradiated LGADs
- Good robustness to radiation: operate at -30°C to mitigate the impact of radiation
- LGADs prototypes (from different vendors) meet HGTD requirements

→ **Ongoing:** sensor pre-production

→ **Next step:** test the pre-production to check they still meet the performance targets

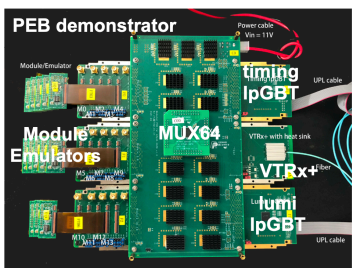


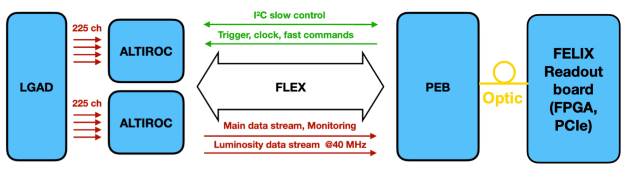


Peripheral Electronics Board

- On detector electronics: lpGBT (Low Power Giga Bit Transceiver), DC-DC converter, VTRX+, multiplexer
- Managing data transmission, power distribution, control and monitoring of the system

→ **Ongoing:** Work on the characterisation of individual components, prototypes under fabrication

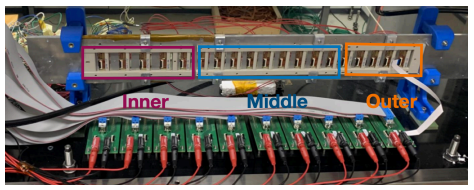




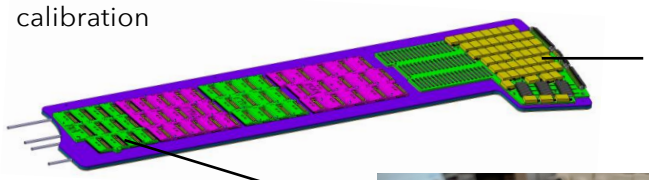
Demonstrator

Prototypes used to validate design and integration:

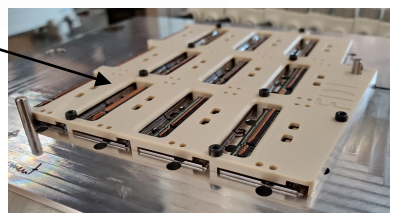
- Heater demonstrator (**done**): study thermal performance with 13 silicon-based heater and validate the module loading procedure



- DAQ demonstrator (**ongoing**): to develop the full chain readout for timing and luminosity data and validate the PEB
- Full demonstrator (**next step**): to validate the full system integration and to test the electronics calibration



54 modules on **detector units** mounted on the cooling plate



References: [1] CERN-LHCC-2023-007-TDR-31 [2] 2023 JINST 18 P05005 [3] 2023 JINST 18 P08019